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Suitability of Nullah Water for Casting of M20 Grade of Concrete Compared to Tap Water

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Abstract—*The study carried out to find out the effect of impure water on the compressive strength of M20 Grade of concrete compared to tap water using Portland Slag Cement (PSC) as locally available water at the sites are used randomly for casting without checking the quality of water though quality of other ingredients is checked highly. Here, the source of impure water is nullah (khal) situated at 150 m from our college campus and another source is the college supplied tap water. Cubes are casted as per IS 10262-2009 and 28 days compressive strength are calculated using both the water. The result showed that the target strength may be achieved for M20 with higher w/c ratio using tap water compared to nullah water. In other words, approximately 43 kg cement may be saved per m3 of concrete casting using tap water compared to nullah water. Also quality of water as pH, Hardness, Chloride content and Turbidity are measured and checked according to IS 456-2000 for reinforced concrete. The result showed that the nullah water is very hard, almost neutral compared to tap water but not suitable for reinforced concrete as it contains very high chloride content which exceeds the limit given by IS 456-2000. Nullah water may be used in PCC but it should be uneconomical compared to use of tap water.*

Keywords*: Nullah, Chloride, PSC, Quality, M20*

1. INTRODUCTION

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Water is the key element among the other ingredients of concrete which form a paste after reacting with cement and strengthen the concrete through hydration process. Very high water decreases the concrete strength while very less water will make the concrete unworkable. On the other hand, water-cement ratio is the main factor to make a strong, durable and economical concrete. Concrete made with impure water restricts the hydration processes; prevent good bonding etc which ultimately weaken the concrete and causing problems in setting or in premature failure of the structure. So, to produce a strong and workable concrete, quality of water is too much important with the amount of water. In practice, there is no control made on the quality of water specially for making one or two storied building and many smaller structures though very high control is exercised in case of aggregates and cement. They used locally available water at the site for casting and ultimately, the structure becomes less durable and uneconomical. Kucche.K, Jamkar.S, Sadgir.P [3] [2015] worked on effect of impure water on compressive strength & split tensile strength by determining the pH of water. They observed that both the strength is greatly reduced for less pH value & corrosion of steel occurs for pH less than 3. Nikhil.T. Et.Al. [2] [2014] were studied about the comparison of effect on compressive & flexural strength with Potable and sewage water & observed that there is an increase of 33.34% of compressive strength & 11.12% of flexural strength for Potable water compared to sewage water. Ojoawo.S, Oladejo.A Olaniyan.O [4] [2014] focused on contamination effect of chloride ions on cube compressive strength of concrete & concluded that there is no significant effect of chloride salt in compressive strength of concrete upto 28 days, but for more than 56 days strength, compressive strength reduces with an increase in chloride ion concentration. ATA Olugbenga [5] [2014] worked on different sources of water & their impact on strength of concrete by determining pH value & reported that for pH value 6-8, there is no significant effect on 28 days cube compressive strength of concrete. Rakesh.A, Dubey.S [1] [2014] showed that 7 days compressive strength of concrete made with waste water sample with a w/c ratio of 0.5 was about 20% less than that of concrete made with tap water. The tensile strength to compressive strength ratio for drinking water & waste water was 7.5.

2. SAMPLING

Two different types of water namely, nullah water and tap water are taken for the present study. Nullah water is taken from nullah which is situated at a distance of 150m from college campus and another water is taken as college supplied tap water.

Fig. 1. Collection of nullah water

Fig. 2. Collection of tap water

3. METHODOLOGY

At first, mix proportion for M20 grade of concrete is found out using IS 10262-2009 & relevant codes with locally available material. All necessary tests of aggregate (coarse & fine) & cement are carried out for the study. Here for casting the cubes, the amount of water is same, but type & quality of water is different.

Fig. 3: Concrete cubes casted using tap water

Fig. 4: Concrete cubes casted using nullah water

Fig. 5: Concrete cube in CTM

Fig. 6: Failure pattern

Fig. 7: Determination of pH

Fig. 8: Determination of Chloride Concentration

Fig. 9: Determination of Hardness

Fig. 10: Determination of Suspended Solid

3 cubes of each water/cement ratio 0.40, 0.45 & 0.50 are casted for nullah water & tap water separately. 28 days compressive strength is calculated & the optimum w/c ratio is determined to achieve target characteristic strength by plotting c/w ratio vs compressive strength graph. Comparative study of strength for both the water is represented. To identify the cause of strength variation, different chemical analysis like pH, Hardness, Chloride concentration, suspended solid determination for both tap water and nulluh water are done. The result & necessary calculations are reported in the next article.

3.1 Sieve Analysis

All The mix proportion is determined according to IS 10262-2009 and relevant code as follows –

3.1.1 Sieve Analysis of Coarse Aggregate

Table 1: Sieve Analysis for 10mm size Coarse Aggregate (C.A II)

Total weight taken = 5 kg

Sieve Size	Weight of retained material (kg)	Cumulative percentage of retained	Cumulative percentage of passing	Percentage of passing
20	0.036	0.72	0.72	99.28
10	0.073	1.46	2.18	97.82
4.75	3.233	64.66	66.84	33.16
2.36	1.007	20.14	86.98	13.02
Pan	0.635	12.7	-	-

Table 2: Sieve Analysis for 20mm size Coarse Aggregate (C.A I)

Total weight taken = 5 kg

Sieve Size	Weight of retained material (kg)	Cumulative percentage of retained	Cumulative percentage of passing	Percentage of passing
40	0	0	0	100
20	1.41	28.2	28.2	74.8
10	2.67	53.4	81.6	18.4
4.75	0.82	16.4	98	2.0

Here both the aggregates are not matching with the T- 2 of IS 383:1970. So we are mixing 20 mm size aggregate and 10 mm size aggregate in a particular ratio to get a standard nominal size of the coarse aggregate. By trial and error method we have calculated the percentage of 20 mm size aggregate is 80% and 10 mm size aggregate is 20% and the following table is obtained.

Table 3: Grading of Coarse Aggregate

Sieve size	Percentage passing	Remarks
40mm	100	Confirm T-2 IS 383-1970
20mm	79.7	
10mm	34.3	
4.75mm	8.2	
2.36mm	2	

3.1.2 Sieve Analysis of Fine Aggregate

Table 4: Sieve Analysis for Fine Aggregate

Total weight of sample taken = 1kg

IS Sieve size	Weight of retained material(kg)	Percentage Wt. retained	Cumulative percentage retained	Percentage passing	Remarks
10 mm	0	0	0	100	Confirm zone III T-4 IS 383-1970
4.75 mm	0.015	1.5	1.5	98.5	
2.36 mm	0.015	1.5	3	97	
1.18 mm	0.121	12.1	15.1	84.9	
600 µ	0.248	24.8	39.9	60.1	
300 µ	0.416	41.6	81.5	18.5	
150 µ	0.168	16.8	98.3	1.7	
Pan	0.005	-	-	-	

3.2 Physical Properties

3.2.1 Specific Gravity of Coarse Aggregate

i) Weight of saturated surface dry sample (A) = 1.0 kg

ii) Weight of sample + water + container (B) = 1.858 kg

iii) Weight of water + container (C) = 1.212 kg

iv) Weight of oven dried sample (D) = 0.992 kg

Absolute specific gravity = 2.8
Apparent specific gravity = 2.86
Percentage of water absorption = 0.4%

3.2.2 Specific Gravity of Fine Aggregate

i) Weight of saturated surface dry sample (A) = 0.5 kg

ii) Weight of sample + water + container (B) = 1.823 kg

iii) Weight of water + container (C) = 1.549 kg

iv) Weight of oven dried sample (D) = 0.498 kg

Absolute specific gravity = 2.204

Apparent specific gravity = 2.223

Percentage of water absorption = 0.4%

3.3 Mix Design

3.3.1 Design Stipulation

a)	Grade of concrete	M20
b)	Type of cement	PSC
c)	Nominal size of aggregate	20mm
d)	Workability	100mm by slump
e)	Exposure condition	Moderate
f)	Method of concrete placing	By hand
g)	Degree of supervision	Good
h)	Type of aggregate	Crushed angular

Test data for materials

a)	Cement used	PSC (confirming to IS:455)
b)	Specific gravity of cement	3
c)	Specific gravity of	
i.	Coarse aggregate	2.86
ii.	Fine aggregate	2.22
d)	Free (surface) moisture	
i.	Coarse aggregate	Nil
ii.	Fine aggregate	Nil
e)	Grading of aggregates	
i.	Coarse aggregate	20mm nominal size
ii.	Fine aggregate	Zone III (Confirming to T-2 IS 383)

Calculation of Mean Target Strength

$$f'_{ck} = f_{ck} + 1.65S$$

Where, f'_{ck} = Target average compressive strength at 28 days and f_{ck} = Characteristics compressive strength at 28 days
S = Standard deviation = 4.0 N/mm^2

[From T-1, IS 10262:2009]
Therefore, target strength = 20 + 1.65 x 4 =26.6 N/mm^2

Calculated Mix Proportion

Casting of cubes are done with the following mix proportion for different w/c ratio.

Table 5: Mix Proportions

w/c Ratio	Mix Proportion (C : F.A : C.A.I : C.A.II)
0.40	1 : 0.98 : 1.96 : 0.49
0.45	1 :1.16 : 2.2 : 0.557
0.50	1 : 1.36 : 2.5 : 0.623

4. RESULTS

Average compressive strength obtained for each w/c ratio and for both type of water, are represented below in a tabular form and two graphs are plotted between compressive strength vs c/w ratio from which optimum w/c ratio is determined corresponding to mean target strength.

Table 6: Compressive strength of cubes casted using tap water

Water-cement ratio	Cement-water ratio	Compressive strength (N/mm2)	Average Compressive strength (N/mm2)
0.4	2.5	32.264	31.6
		31.174	
		31.392	
0.45	2.22	30.520	29.1
		28.994	
		27.904	
0.5	2	27.25	25.9
		25.07	
		25.288	

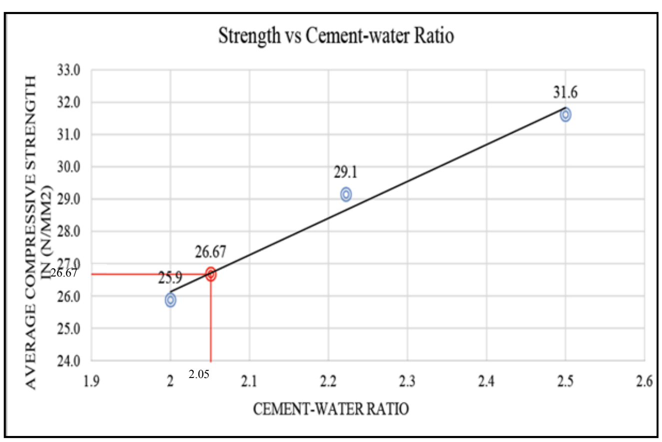

Fig. 11: Strength vs C/W Ratio for Tap Water

Table 7: Compressive strength of cubes casted using nullah water

Water-cement ratio	Cement-water ratio	Compressive strength (N/mm2)	Average Compressive strength (N/mm2)
0.4	2.5	27.9	28.7
		28.2	
		30	
0.45	2.22	27.3	27.4
		27.3	
		27.6	
0.5	2	23.1	23.0
		22.2	
		23.7	

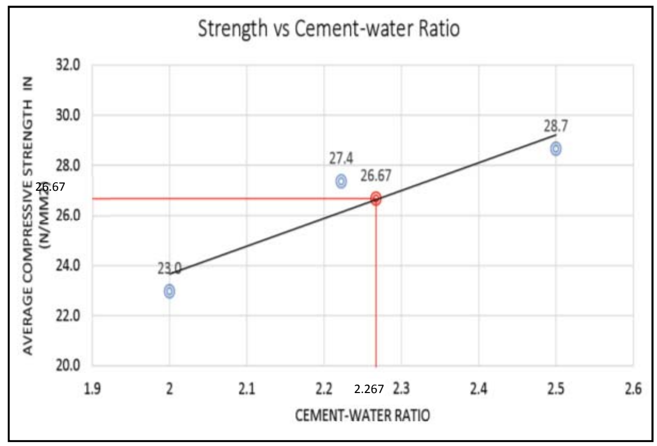

Fig. 12: Strength vs C/W Ratio for Nullah Water

5. DISCUSSION

From the Fig. 11, for tap water the c/w ratio is 2.05. So, w/c ratio is 0.488. From the Fig. 12, for nullah water the c/w ratio is 2.267. So, w/c ratio is 0.441. According to mix design, water content is 197.16 kg/m^3. So, cement content for tap water concreting is (197.16/0.488) = 404 kg/m^3. But that for nullah water concreting is (197.16/0.441) = 447 kg/m^3. Therefore 43 kg cement is saved for 1 m^3 plain cement concreting work. It should not be used for reinforced concrete as chloride content exceed the limit as given in T-1, IS 456-2000. It is clearly noticeable that the strength is reduced by using nullah water instead of tap water for same cement content.

Table 8: Comparative Study on Chemical Analysis of Two Types of Water

SL. No.	Experiment Name	Tap water	Nullah water	Allowable Limit as per IS 456-2000	Remarks
1	pH	6.9	7.12	>6	Both are acceptable

2	Chloride concentration	432 mg/l	712 mg/l	2000 mg/l for concrete not containing embedded steel & 500 mg/l for R.C.C work	Tap water is suitable for both P.C.C as well as R.C.C, but Nullah water is not suitable for only R.C.C work
3	Hardness	212 mg/l	480 mg/l	-	Nullah water is very hard
4	Suspended Solid concentration	629 mg/l	2200mg/l	2000 mg/l	Nullah water is not acceptable

6. CONCLUSION

1) Nullah water is not suitable for RCC from chloride point of view.

2) Nullah water may be used for PCC but it will give uneconomical concrete.

3) Nullah water contains high amount of suspended solid which exceeds the limit given by T-1, IS 456-2000, So nullah water is not acceptable for concreting.

4) Always tap water should be recommended for casting of M20 grade of concrete, in spite of nullah water.

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